

**ATTACHMENT A**

**INDUSTRIAL CERAMIC SHAPED BODY AND  
PROCESS FOR PRODUCING SAME**

**CROSS REFERENCE TO RELATED APPLICATION**

**[0001]** This application claims priority to PCT/EP2003/10808 September 29, 2003 and DE 102 59 826.6 filed December 19, 2002.

**FIELD OF THE INVENTION**

**[0002]** The invention relates to a fired, basic, refractory, industrial ceramic, elasticized shaped body based on at least one resistor component such as magnesia and dolomite. In addition, the invention relates to a process for producing the shaped body and to its use.

**BACKGROUND OF THE INVENTION**

Shaped bodies of the generic type are used as refractory lining, in particular in high-temperature processes involving exposure to basic slag, e.g. in furnaces, tanks or vessels in the cement, lime, dolomite, magnesite, steel and nonferrous metals industries and also in the glass industry.

**[0003]** Although a shaped body composed of a resistor component (hereinafter also referred to simple as resistor) such as MgO or CaO/MgO (dolomite) has a high fire resistance and good chemical resistance, it is generally brittle because it has a relatively high modulus of elasticity (E) and an unfavorable shear modulus (G). This has an adverse effect on, in particular, the dissipation of thermal stresses, the mechanical stressability and the thermal shock resistance (TSR). It is therefore desirable to set low elastic moduli because these affect the thermomechanical durability.

**[0004]** To increase the elasticity or to reduce the elastic moduli, it is known that it is possible to add an elasticizer component (hereinafter also referred to simply as elasticizer) to a mix for producing a shaped body or to add raw materials which generate the elasticizer in the mix during ceramic firing.

**[0005]** For example, magnesia-chromite bricks or magnesia-spinel bricks which display usable shear moduli in the range from 8 to 12 GPa (gigapascal) are produced using chromium ores or synthetic spinel.

**[0006]** Refractory bricks containing molten hercynite or molten zirconium oxide as elasticizer have a low elasticity but are ductile. The shear moduli are from about 15 to 20 GPa and therefore relatively high.

**[0007]** These known elasticized, basic, refractory shaped bodies are evaluated, in particular, in respect of elasticity, desired deposit formation in a rotary tube furnace, redox resistance, alkali resistance, hydration resistance and disposability, with each of these known shaped bodies having, in terms of these properties, advantages and disadvantages, which can be seen from the following table:

**Table 1: Qualitative properties of known shaped bodies**

	<b>Magnesia- spinel brick</b>	<b>Magnesia- hercynite brick</b>	<b>Magnesia- chromite brick</b>	<b>Magnesia- zirconia brick</b>	<b>Dolomite brick</b>
<b>Elasticity</b>	good	poor	good	good	poor
<b>Deposit formation</b>	poor	good	good	poor	good
<b>Redox resistance</b>	good	poor	poor	good	good
<b>Alkali resistance</b>	good	poor	poor	good	poor
<b>Hydration resistance</b>	good	good	good	good	poor
<b>Disposability</b>	good	good	poor	good	good

**[0008]** Magnesite-spinel bricks and magnesite-zirconia bricks form a stable deposit in a rotary tube furnace only with difficulty; they consequently have only limited usability in, for example, the sintering zone of a rotary tube furnace for cement. Although magnesite-hercynite bricks display good deposit formation, they have a poor redox resistance and alkali resistance. The same applies to magnesite-chromite bricks which are additionally known to create disposal problems. Dolomite bricks containing no elasticizer do ensure very good deposit formation but are neither sufficiently alkali resistant nor sufficiently hydration resistant.

**[0009]** It is an object of the invention to provide a basic, elasticized, refractory shaped body which combines high fire resistance and good chemical resistance

with, in particular, good elasticity and good deposit formation capability, and good redox, alkali and hydration resistance and can be disposed of without problems.

#### SUMMARY OF THE INVENTION

**[0010]** According to the invention, sintered magnesia and/or fused magnesia or sintered dolomite and/or fused dolomite, selected from among the numerous known resistors, is/are used as basic resistor. Calcium aluminate having a  $\text{CaO}/\text{Al}_2\text{O}_3$  ratio of from 0.14 to 0.2, in particular of the chemical composition  $\text{CaAl}_{12}\text{O}_{19}$  having the oxide formula  $\text{CaO} \cdot 6\text{Al}_2\text{O}_3$  or the abbreviated formula  $\text{CA}_6$ , has been found as an elasticizer.

**[0011]** Calcium hexaaluminate has the chemical formula  $\text{CaAl}_{12}\text{O}_{19}$  or the mineral name "hibonite" and the oxide formula  $\text{CaO} \cdot 6\text{Al}_2\text{O}_3$  or the abbreviated formula  $\text{CA}_6$ .

**[0012]** The  $\text{Al}_2\text{O}_3$  of the  $\text{CA}_6$  does not react with the alkali metal and calcium compounds, e.g. in the rotary tube furnace for cement, because it is already saturated with CaO. This results in a very good corrosion resistance. The CaO in the  $\text{CA}_6$ , which is also the main constituent of the cement clinker material, probably ensures very effective deposit formation in the rotary tube furnace, which cannot be achieved even with the deposit-forming, known, elasticized, refractory shaped bodies such as magnesia-hercynite bricks or magnesia-chromite bricks.

**[0013]**  $\text{CA}_6$  is not an unknown in refractory materials. A refractory shaped body whose mineral oxidic component is formed by a mineral phase mixture of  $\alpha\text{-Al}_2\text{O}_3$ ,  $\beta\text{-Al}_2\text{O}_3$ ,  $\text{CA}_6$  and  $\text{CA}_2$  is known. The mineral phase mixture is said to increase the corrosion resistance of the shaped bodies.  $\text{CA}_6$  does not play an elasticizing role here.

## DETAILED DESCRIPTION AND EXAMPLES OF THE INVENTION

**[0014]** The invention is illustrated below with the aid of an example:

**[0015]** Magnesia having a maximum particle size of 4 mm and a particle size distribution corresponding to a typical Fuller curve and the mineral calcium hexaaluminate having a particle size range from 0.5 to 4 mm were mixed, admixed with a required amount of lignin sulfonate as binder, shaped to form bricks and pressed at a specific pressing pressure of 130 MPa. After drying at 110°C, the bricks were fired at a sintering temperature of 1600°C in a tunnel kiln.

**[0016]** The achieved properties of the fired bricks as a function of the amount of calcium hexaaluminate added are shown in table 2 below. A magnesia brick fired in the same way was employed as comparison.

**Table 2:** *Properties of shaped bodies according to the invention compared to properties of a magnesia brick*

<b>Magnesia</b>	<b>% by mass</b>	100	92	84	76
<b>CA<sub>6</sub></b>	<b>% by mass</b>	-	8	16	24
<b>Overall density</b>	<b>g/cm<sup>3</sup></b>	2.99	2.99	2.98	2.97
<b>Porosity</b>	<b>%</b>	16.12	16.26	16.42	16.41
<b>CCF</b>	<b>MPa</b>	75.30	72.20	71.10	71.40
<b>CFS</b>	<b>MPa</b>	12.10	6.10	5.80	5.50
<b>Modulus of elasticity</b>	<b>GPa</b>	91.90	31.20	27.10	22.80
<b>Shear modulus</b>	<b>GPa</b>	41.50	12.80	11.40	10.60
<b>TSR</b>		15	>100	>100	>100

**[0017]** It can be seen from table 2 that the bricks according to the invention are sufficiently elasticized for use in a rotary tube furnace for cement with its temperature-dynamic conditions. The elastic moduli are within a very good range. The thermal shock resistance (TSR) is excellent.

**[0018]** The mechanism which leads to the very good elasticization of the bricks has hitherto not been able to be determined unambiguously. There is presumably microcrack formation between the magnesia matrix and the calcium hexaaluminate during firing of the bricks, caused by the difference in the thermal expansion of these two materials.

**[0019]** Table 3 below shows the individual relevant properties of the known shaped bodies of table 1 and those of the shaped bodies according to the invention.

**Table 3:** *Qualitative properties of known shaped bodies compared to a shaped body according to the invention*

	<b>Magnesi a-spinel brick</b>	<b>Magnesi a- hercynite brick</b>	<b>Magnesi a- chromite brick</b>	<b>Magnesi a- zirconia brick</b>	<b>Dolomit e brick</b>	<b>Magnesia -CA<sub>6</sub> brick</b>
<b>Elasticity</b>	good	poor	good	good	poor	good
<b>Deposit formation</b>	poor	good	good	poor	good	good
<b>Redox resistance</b>	good	poor	poor	good	good	good
<b>Alkali resistance</b>	good	poor	poor	good	poor	good
<b>Hydration resistance</b>	good	good	good	good	poor	good
<b>Dispos- ability</b>	good	good	poor	good	good	good

**[0020]** Table 3 shows that all the types of brick known hitherto have significant disadvantages in terms of the application-relevant properties. In contrast, the magnesia-CA<sub>6</sub> bricks of the invention have exclusively good properties, as have hitherto not been known in their use-relevant combination.

**[0021]** Shaped bodies according to the invention can be used advantageously wherever severe temperature changes occur and wherever mechanical and thermomechanical stresses occur. These are, for example, sintering and transition

zones of rotary tube furnaces in the brick and earth industry, in particular the cement, lime, dolomite and magnesite industries, ferrous and nonferrous metals industry and also melting and handling vessels in the iron or steel industry and the nonferrous metals industry. A shaped body according to the invention displays excellent usage performance in respect of hydration, alkali, redox and corrosion resistance combined with good deposit formation tendency. It is thus also superior to the known products after use because of unproblematical disposal possibilities.

**[0022]** The elasticization of the basic shaped bodies according to the invention can be achieved using not only pure calcium hexaaluminate, but it is also possible for secondary phases, e.g.  $\text{SiO}_2$  and/or  $\text{TiO}_2$  and/or  $\text{Fe}_2\text{O}_3$  and/or  $\text{MgO}$ , to be present in amounts of up to 10% by mass in the calcium hexaaluminate. Furthermore, the calcium hexaaluminate also has the action described when up to 58% by mass of the  $\text{Al}_2\text{O}_3$  has been replaced by  $\text{Fe}_2\text{O}_3$  or when  $\text{Ca}^{2+}$  has been partly replaced by  $\text{Ba}^{2+}$  or  $\text{Sr}^{2+}$ .

**[0023]** While the above description constitutes the preferred embodiment of the present invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope and fair meaning of the accompanying claims.